STUDIES OF PEROSIS IN GROWING CHICKS

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INTRODUCTION

Perosis, a leg disorder of growing chicks, has recently become the cause of a considerable loss to poultry producers. The loss appears to be greatest under intensive methods of brooding in battery brooders. In experimental work the development of this disorder in a severe form interferes with the results obtained in feeding tests. As the cause, or causes, of this disorder are not definitely established, nor the mechanism by which it develops fully understood, this study was undertaken to make a contribution to the knowledge on this subject. In view of the varying incidence of perosis reported by producers throughout the Province, using standard chick rations, it was thought advisable also to test these rations as to their suitability for raising chicks under the varying conditions encountered.

SYMPTOMS OF PEROSIS

Payne (17) is one of the first workers to describe the symptoms of a leg disorder in young growing chicks, known at that time under the various names, leg-weakness, rickets, enlarged hock joint, slipped tendon and malformed leg bones.

According to this worker, in chickens between the ages of 3 to 6 weeks the hocks become enlarged, due probably to oedema and slight hemorrhages in the tissues surrounding the joints. The gastrocnemius tendon which extends the foot and flexes the leg, occasionally slips from the condyles which hold it in place. This may be responsible for the stiffening and malposition of the legs below the hock joint, found in advanced cases. Either the femur, or the tibia, or both, may become enlarged or develop marked curvature. One or both legs may be involved. The legs may be bowed in or out, or become deformed into unusual shapes.

Doyle (3) considers "slipped tendon" to be essentially a bending or torsion of the bones which form the hock joint, with a consequent displacement of the Achilles tendon. He also considers the presence of whitish-grey tumorous masses in and along the bones, very frequently in the visceral organs and sometimes in the skeletal muscles, to be characteristic of this disease.

Hunter and Funk (9), from examination of the legs of affected birds, report enlargement of the hocks and a slipping of the gastrocnemius tendon from its normal position in the groove back of the leg to a new position at the side of the joint. In dissection studies they find that after the tendon has slipped it proliferates around the joint and strengthens it, but leaves the leg in a permanently deformed condition.

Titus (23) sets out very clearly his observations on perosis. According to this worker, the first noticeable symptom is a tendency for the chicks to rest for long periods of time in a squatting position. At this time a slight puffiness of the tibio-metatarsal joint may be observed on careful examination. In the next few days there is pronounced enlargement and, in some cases, discoloration, due to hemorrhages in the underlying tissues. These symptoms may occur any time after the third week up to the seventh week and may be only temporary, the birds recovering so that scarcely any noticeable permanent deformity results. If these symptoms do not subside the tibiae and tarso-metatarsi exhibit a slight bending which is readily apparent when the legs of the chicks are X-rayed. Gross deformity results from a continued curving of these bones. Titus refers to this stage as "deformed leg bones". Frequently the articular cartilage at the distal end of the tibia slips slightly from its normal position and this in turn appears to cause the main tendons to slip from their condyles leaving the joint permanently disabled. The curvature of the diaphysis of the tibia may be so great at the distal end that the tendon slips, even though the articular cartilage has not been displaced. Titus refers to this stage as "slipped tendon".

Milby (14) has presented his observations on the symptoms in this disorder affecting the tibio-metarsal (hock) joint. In chicks two to ten weeks of age, he states the first noticeable symptom is usually a slight puffiness about

the hock joint. At this time the tibia is usually straight but the metatarsus may be slightly bowed. In some cases the gastrocnemius tendon slips from the condyles to one side or the other. Some chicks recover and in these cases the hocks apparently return to normal. In other cases the hocks become flattened laterally and the legs are bowed. Frequently the chick is no longer able to stand but rests on its hocks with the feet extended to the front or side. Affected chicks usually act as if standing were painful to them. The tibia and metatarsus become bent. The epiphysis at the distal end of the tibia is always bent laterally in the direction in which the tendon slips, and the extent of the bending appears to be roughly proportional to the severity of the deformity. Bending of the distal end of the tibia has not been observed in chicks not afflicted with slipped tendon and Milby considers it probable that the bending is the result and not the cause of the displacement of the tendon.

REVIEW OF LITERATURE

Only in recent years has perosis been accepted as a distinct disorder. Previously it was confused with rickets and grouped along with other leg disorders as "leg weakness". The normal ash content of the leg bones of chicks with perosis, as reported by several workers (6) (8) (14), indicates that at least one of the findings in this disorder is not characteristic of rickets or osteoporosis. Titus (23) as a result of gross osteological

examination concluded that the similarity between perosis and rickets was more apparent than real. Milby (14) although agreeing that perosis is a distinct disorder, considers that the bending of the bones indicates that gross bone anatomy has been disturbed in some way and that the relationship of slipped tendon to rickets is by no means settled.

Doyle (3) divides "leg weakness" in chicks into three groups on the basis of tissues affected:

(1) Diseases affecting the bones,

(2) Diseases affecting the nervous system,

(3) Conditions affecting the muscles and tendons.

He places slipped tendon in group (1) as being essentially a bending or torsion of the leg bones which form the hock joint, with a consequent displacement of the Achilles tendon.

Payne (17), as a result of observations made, considers that the trouble is not confined to any group of conditions. It may be found in slow and rapid growing chicks, with mash or grain and mash rations, on wire or on board runways. The author also considers that the disorder will develop in chicks on rations having a high or a low mineral level.

Herner and Robinson (6) describe a condition produced in chicks on a ration high in meat scrap and containing adequate vitamin D. They record the following symptoms: digestive disorders followed by thick hocks, short shanks, bow-legs, twisted legs, and slipped tendon, and conclude that these conditions are produced by a high level of minerals in the ration. Chemical analysis revealed no abnormality in

the ash, calcium or phosphorus content of the leg bones of affected birds, and the authors conclude the malformation is non-rachitic.

Holmes, Pigott and Moore (8) find no significant difference in the mineral content or size of tibia from "slipped tendon" and from normal chicks on the same ration, comparisons being made at three, six and nine weeks of age. They present evidence which indicates that excessive mineral feeding is a factor in increasing the percentage of slipped tendon.

Hall and King (4) also find that the deformity in "slipped tendon" is not due to abnormal composition or structure of the leg bones. From a histological and chemical examination the bones appear to be normal. By X-ray the only abnormal findings are subluxation, bowing and rotation.

Schaible, Moore and Conolly (19) produced perosis by feeding high levels of minerals supplied from bone meal, bone ash, $Ca_3(PO_4)_2$, $MgCO_3$, or a mixture of $CaCO_3$, Na_2HPO_4 and KH_2PO_4. Additions of 5% oyster shell or 4% Na_2HPO_4 to the basal ration did not produce perosis. Variation in the acid-base balance, in the Ca:P ratio, and in the source of protein supplement of a high mineral ration, was found to influence the incidence of perosis. Soy bean oil meal, comprising 10% of the protein of a high mineral ration, was found to have a highly protective effect. No difference in susceptibility was found in birds of different sizes. However, males were found to be more susceptible than females.

Henderson (5) suggests that the malformation in the leg bones of chicks raised in battery brooders, which he designates as "rickets", and which occurred in the presence of adequate vitamin D, is probably due to excess calcium or phosphorus, or both, in the ration. He found that when calcium and phosphorus each exceeded 1.8% of the total ration, a high percentage of deformities and retarded growth resulted. Egg yolk and chicken fat failed to prevent the development of the deformity.

Payne, Hughes and Leinhardt (18) conclude, as a result of histopathological study of the organs and tissues, and a chemical analysis of the blood and leg bones, that the condition known as "slipped tendon" is of an anatomical rather than histological nature. Excessive amounts of calcium or phosphorus, or both, in the ration are considered important etiological factors in the production of slipped tendon. The authors also find that a mineral mixture of c.p. $Ca_3(PO_4)_2$ and $CaCO_3$ produce the same deformities as an equivalent amount of steamed bone meal. With regard to the actual mechanism by which the deformity is produced, the authors are of the opinion that, due to the failure of the tendon to keep pace with the increase in length of the leg bones, it slips from its normal position in the hock joint and pulls the leg around, resulting in a deformed condition.

Heller, Zimmerman and Thompson (7) state that skiagrams of bones of chicks with slipped tendon show a faulty bone formation which is not cured by vitamin D but is cured by a correction of the level of phosphorus in the ration. They

consider attempts to correlate inorganic phosphorus of the blood with incidence of slipped tendon to be of little value due to the relatively large proportion of serum phosphorus in organic combination.

Wilcke (24) (cited by Milby (14)) found no significant difference in the plasma calcium, inorganic phosphorus, and ash determinations made on chicks with slipped tendon and on apparently normal chicks from the same pen. With a limited number of chicks there was no difference in the incidence of slipped tendon as the Ca:P ratio of the ration was varied, (1:1, 2:1, and 3:1) providing the level of phosphorus remained unchanged (P. = .624%). However, when the level of phosphorus was increased to 1.22% with a Ca:P ratio of 1.18:1 there was a marked increase in the percentage of slipped tendon.

Insko, Sowell and Lyons (11) outline the stages in which they consider slipped tendon develops:

(1) Enlargement of the hock joint and discoloration due to hemorrhage in the underlying tissue.

(2) Curvature of the tarso-metatarsi and tibiae.

(3) Slipping of the gastrocnemius tendon from the articular cartilage.

They consider the level of phosphorus in the ration to be an important precursor of slipped tendon. As the bone meal content of the ration was increased, with an accompanying increase in phosphorus (Ca:P ratio remaining approximately the same) there was a decided increase in the percentage of slipped tendon. A widening of the Ca:P ratio from 0.4:1 to 3:1 by the addition of calcium to the ration did not increase

the percentage of slipped tendon although there was a noticeable decrease in the average weight of the chicks at ten weeks of age.

Milby (13) reports a statistical study of 65 lots of chicks in which slipped tendon occurred. Correlations of the percentage of slipped tendon and the percentage of protein, ash, calcium and phosphorus of the ration were calculated. The only significant correlation was found to be between the level of phosphorus in the ration and the incidence of slipped tendon. However, as the author states, these results do not justify the conclusion that phosphorus is the chief causative factor of slipped tendon but merely indicate that high percentages of slipped tendon are associated with high phosphorus in the ration.

Branion (2) presents the results of a three year study of the influence of different cereal grains on the quality of bone formed in the first twelve weeks of life. Chicks raised on otherwise apparently adequate diets, but with corn meal as the sole cereal grain, had a high percentage of abnormal leg bones, including bending and bowing, as well as slipped tendon. This condition had apparently no association with the Ca:P ratio, nor with the total mineral content of the ration, although the latter, if excessive, apparently aggravated the condition. The author concludes that corn contains a constituent responsible for the production of slipped tendon, the activity of which is reduced by the inclusion of wheat germ, oat hulls and germ, or of complete oats in the ration. In addition, barley was found to produce a porous,

spongy bone similar to that produced by corn, but the incidence of slipped tendon on the barley ration was very low unless the mineral content of the ration was excessive.

Titus and Ginn (22) replaced 10% and 20% of wheat, in a ration that produced perosis, with equal amounts of rice bran and report that no perosis developed when the rice bran was included. In view of these and additional results obtained, the authors consider that perosis may be prevented by the addition of 6 to 10% of rice bran to the ration, providing the Ca:P ratio is adjusted to the optimum, (2.5:1). In view of their findings (1) that the ash content of the leg bones is normal, (2) the calcium and inorganic phosphorus of the blood serum falls within the normal range, the authors consider that perosis is not a truly rachitic condition. They also consider that in addition to vitamin D another accessory food factor or vitamin is necessary for the proper development of the leg bones of the chick.

Titus (23) confirms the preventive action of rice bran as reported by (22) and considers this action to be due to a substance, vitamin in nature, which promotes normal bone development. He made an unsuccessful attempt to extract the active factor in rice bran with ether but found that the residue from ether-extracted rice bran retained the power to prevent perosis.

Hunter, Knandel and Dutcher (10) report a so-called preventive factor for slipped tendon. They found that oats and oat feed possessed beneficial properties that could not

be accounted for on the basis of fibre content. They also found that the abnormality could be produced by additions to the basal ration of calcium or phosphorus, or both, and could be brought about under a variety of Ca:P ratios.

Sherwood and Couch (21) found that a basal ration containing corn as the only cereal and having a phosphorus level of .51% produced 10 to 15% of slipped tendon. When 12% of dried buttermilk in the basal ration was supplemented by 15% of meat scrap, increasing the phosphorus level to 1%, the percentage of perosis was increased to 80. Rice bran or wheat middlings added to this ration at the expense of corn, definitely prevented slipped tendon at phosphorus levels up to 1% of the ration. From their work they conclude that there are two or more factors responsible for slipped tendon: (1) A lack of mineral balance in the ration, ~~is considered to be an important factor in producing slipped tendon~~. (Their results indicate that as the phosphorus level increases in the ration, the number of cases of slipped tendon is increased, and as the calcium level increases the number of cases of slipped tendon decreases.) (2) A factor, active in preventing slipped tendon, which is present in appreciable amounts in rice bran and wheat grey shorts, and possibly present in lesser amounts in oat groats and cottonseed meal.

Bethke and Record (1) conclude that excessive amounts of calcium and phosphorus are important factors in the production of slipped tendon. They also observe that males are apparently more susceptible than females and that slipped

tendon is more prevalent in the heavier than in the lighter breeds.

Hunter and Funk (9) found that in chicks raised in battery brooders, the addition of bone meal, meat and bone meal, or NaH_2PO_4 to a basal ration increased the incidence of perosis from 0 to 80%. They conclude that the mineral content of the ration is an important etiological factor in the production of slipped tendon, and group lack of exercise, brooding on wire and crowded conditions as important contributing factors.

Milby (14) finds that with rations otherwise adequate for normal growth, phosphorus appears to be the chief causative factor in the production of slipped tendon; 0.9% phosphorus was found to be the lowest level at which slipped tendon was produced. As the phosphorus level was increased, up to 1.33%, the percentage of slipped tendon was increased to 79% in males and 76% in females. The author also finds no significant difference in the ash content of the femurs, tibiae and metatarsi of chicks having slipped tendon, and that of normal chicks on a control ration at the same age. The ash determinations were made in all cases within a few days of the first manifestation of the disorder. The feeding of rice bran or wheat middlings was also found to be of value in preventing slipped tendon, the percentage of slipped tendon produced by a ration being determined mainly by the relative amounts of phosphorus and of preventive factor present. However, susceptibility of the chicks and various environmental

factors may modify the results produced by the feeding of any ration. By the feeding of 3% $MgCO_3$ in the control ration, the author obtained neither slipped tendon nor marked bending of the leg bones. The growth of the chicks on this ration, however, was significantly lower than that of chicks on the control ration. The ash content of the dry fat-free femurs was reduced by the feeding of $MgCO_3$.

Parkhurst and McMurray (16) have made some general observations on perosis. They consider this disorder may be associated with poor vigor, either inherited or caused by unsatisfactory feeding and management during the early stages of the chick's life. When perosis develops at two to four weeks it may improve and never produce a permanent deformity. However, in chicks lacking in constitutional vigor, the early condition referred to above fails to improve and a permanent deformity may result. The actual slipping of the tendon is considered to be due to a more rapid growth in the leg bones than in the tissues and tendons of the leg. As a result of experimental work they conclude that an excessive amount of meat and bone meal in the ration produces a high percentage of perosis which is markedly reduced when the bone meal content of the ration is reduced. The feeding of $CaCO_3$ did not produce perosis under the conditions of their experiment. The protein content of the ration and the rate of growth did not materially affect the occurrence of perosis. Crowded conditions and lack of exercise were not found to be contributing factors of importance.

Serfontein and Payne (20) present results which indicate the possible inheritance of the tendency toward "crooked legs". They obtained a significant difference in the percentage of crooked legs developing in chicks from matings of crooked leg parents and those from straight leg or normal parents.

McGowan and Emslie (15) in a paper on "Rickets in Chickens," make several comments on perosis. They draw attention to the facts (1) perosis is not prevented or cured by feeding cod liver oil, (2) there is no histological abnormality in the bones examined. The factor most commonly associated with the condition is the presence of large amounts of $Ca_3(PO_4)_2$, as bone meal, in the ration. The authors refer to work done by McGowan in which evidence is presented to support the contention that the metabolism of calcium and phosphorus is less efficiently carried out when these two elements are fed in chemical union with one another. It is suggested that in order to prevent perosis, calcium be fed as the salt of some other radicle than phosphorus, the phosphorus being supplied separately in organic combination. In this way the calcium will be, for the most part, dissolved out and absorbed before the organic (delayed action) phosphorus is in a form to unite with it. The authors suggest that the beneficial effect resulting from the feeding of rice bran may be due to the rich supply of organic phosphorus present in this feed.

EXPERIMENTAL

Chicks Used

Day-old White Plymouth Rock chicks were used in the first four experiments and Rhode Island Reds in the fifth experiment. These heavy breeds were selected in preference to Leghorns as the incidence of perosis is generally found to be somewhat higher in the heavier than in the lighter breeds.

Brooding

For the first six weeks of each experiment an electrically-heated six-deck brooder was used, the heat being discontinued at four weeks. For the next two weeks some of the pens were transferred to a separate, unheated brooder. The chicks in each experiment were discarded at the end of eight weeks. The temperature of the brooder room was kept within a range of 70° to 80°F.

Lighting

To obtain a feeding day of constant length throughout the series, lights were turned on in the brooder room at dusk each day and turned off at 9:00 p.m.

Method of Feeding and Watering

Feed and water were available to the chicks at all times, in troughs placed just outside the gates of each pen. Access to droppings was prevented by keeping the chicks on wire floors.

Rations

The rations were mixed by hand in 10 Kg. lots. The level of protein, calcium and phosphorus was calculated from percentages in Table 1.

Feeds Used

The feeds used, along with their partial chemical analyses, are listed in Table 1.

Table 1

Partial chemical analyses of feeds

Feed Stuffs	% Protein	% Calcium	% Phosphorus
Yellow Corn Meal	10.0	.01	.30
Wheat Chop (fine)	13.19	.02	.35
Oat Chop (medium)	12.59	.04	.31
Oat Groats	16.4	---	---
Barley Chop (fine)	12.70	.02	.26
Standard Wheat Middlings	17.6	.06	.92
Wheat Bran	17.3	.06	1.28
# Rice Bran	13.7	.02	1.30
Alfalfa Leaf-and-Blossom Meal	13.9	1.73	.17
Powdered Skim Milk	32.85	1.24	.85
Pilchard Meal	66.6	4.57	2.46
Meat Scrap	54.6	5.90	2.80
Meat Scrap ("Super 70")	70.7	1.32	1.05
Linseed Oil Meal (N.P.)	39.44	.30	.64
## Marmite (Autolized Yeast)	38.92	.12	1.83
Steamed Bone Meal	25.3	23.1	11.1
$CaCO_3$ (Ground Kootenay Marble)		39.76	
$Ca_3(PO_4)_2$ (precipitated)		38.70	20.0
$NaH_2PO_4 . H_2O$			22.46

A product obtained in the milling of rough rice. It contained rice polish and cracked rice particles in addition to bran.

For comments - See Pen 5, Exp. III.

Recording of Results

All chicks were weighed at 2, 4, 6 and 8 weeks of age. The feed was not removed before weighing. The legs and hock joints of the chicks were examined at the time of weighing. The average weights recorded in each experiment are based on the total number of individuals surviving the test. The total number of cases of perosis, including flattened hocks, twisted legs, bent legs, and slipped tendon, were recorded at the time of each weighing. Only those cases in which recovery on any ration was considered impossible were reported as "slipped tendon". Cases which recovered during the experiment are reported for each two-week period. The percentage of slipped tendon was calculated on the number of chicks in the pen at two weeks of age. Mortalities in the first two weeks were not considered to be caused by perosis. The total percent mortality, however, was calculated from the number of chicks in the pen at the beginning of the experiment.

In Experiments III, IV and V, those chicks severely affected with slipped tendon were removed, at the time when it became evident that recovery was impossible, and their weights do not appear in the tables of average weights. These chicks are recorded as mortalities although the greater number of them were living when removed from the pen.

EXPERIMENT I (Nov. 13/34 - Jan. 9/35)

Objects

(1) To confirm results obtained by Milby (14).

(2) To study the various stages in the development of slipped tendon.

(3) To determine the effect on the development of slipped tendon of varying the source of inorganic phosphorus.

Four uniform groups, each containing 25 chicks, were selected and placed in a small heated brooder for two weeks. For the next four weeks these chicks were kept in four sections in the main heated brooder, then transferred to an unheated brooder when six weeks old.

Rations

1. Control - low phosphorus (non-perosis-producing).
2. High phosphorus with rice bran as preventive.
3. High phosphorus, no preventive factor.
4. Same as 3 but with meat scrap and fish meal used as the main sources of protein and as contributing sources of phosphorus.

Table 2

Constituents of the rations

Feeds	Pen 1	2	3	4
Yellow Cornmeal	55	53.5	68.5	78.5
Wheat Middlings	20			
Rice Bran		20		
Alfalfa L. & B. Meal			5	5
Powdered Skim-milk	20	20	20	3
Meat Scrap				3
Fish Meal				4.5
$Ca_3(PO_4)_2$		3	3	2.5
NaH_2PO_4		1.5	1.5	1.5
$CaCO_3$	3			
NaCl	1	1	1	1
Cod Liver Oil	1	1	1	1
	100	100	100	100

Rations No. 1, 2 and 3 are identical, (as far as can be determined), with those used by Milby (14). The meat scrap used in No. 4 contained an appreciable amount of bone in a coarsely-ground condition.

The estimated composition of these rations is presented in Table 3. The chemical composition of feeds listed in Table 1 was used in formulating this table.

Table 3

Approximate analysis of the rations

Ration No.	% Protein	% Calcium	% Phosphorus
1	15.59	1.46	.52
2	14.66	1.42	1.53
3	14.12	1.50	1.32
4	14.17	1.48	1.30

The analysis calculated from Table 1 corresponds very closely with that presented by Milby (14) for similar rations.

Results of Experiment I

Table 4

Average weights

Pen No,	Sex	2 wks.	4 wks.	6 wks	8 wks.	No. in pen at 8 wks.
1	Male	63	145.2	331.5	545.3	11
	Female	58.7	126.6	275.8	439.4	12
2	Male	73.1	159.1	339.1	557.8	8
	Female	67.5	141.6	290.2	442.5	13
3	Male	71.5	155.5	328.1	503.1	11
	Female	59.3	122.1	248.8	382.7	9
4	Male	74.3	160.0	375.0	600.3	3
	Female	76.6	170.6	334.6	489.0	16

The average weight of chicks living to eight weeks is lowest in the case of Pen 3. This may be explained by the severity of the deformity in the cases which developed, and the consequent difficulty in feeding. In some cases death resulted from starvation. There was considerable individual variation in weight in all pens. These rations all produced poor feathering.

Table 5

Incidence of Perosis

	Pen 1				Pen 2			
Age	No. Chicks	Cases of Perosis	Recov - eries	Slipped tendon	No. Chicks	Cases of Perosis	Recov- eries	Slipped tendon
1 day	24				24			
2 wks.	23				23			
4 wks.	23				23	3		
6 wks.	23				22	3		
8 wks.	23				21	3		1
Total						3		1
Slipped tendon		- 0				4.3%		
Mortality		- 4.2%				12.5%		

	Pen 3				Pen 4			
1 day	25				24			
2 wks.	25				19			
4 wks.	25	11			19	9		1
6 wks.	22	16	1	3	19	14		1
8 wks.	20	18	1	8	19	15	1	11
Total		18	1	8		15	1	11
Slipped tendon		- 32 %				57.9%		
Mortality		- 20%				28.3%		

Discussion of Results

No abnormalities of any kind were observed in the legs of birds in Pen 1. This is in accord with Milby's findings (14) when he used the same ration in three experiments. The preventive action of rice bran as reported by several workers (22) (23) (14) is

confirmed by the results in Pen 2. However, the results are not as definite as obtained by Milby (14) when using the same ration, as one case of slipped tendon (4.3%) developed in this pen and there were two cases of twisted legs. These results may be explained by the fact that the rice bran used by Milby probably differed considerably in composition from that of the rice bran used in these experiments.

The results obtained in Pen 3 do not confirm those obtained by Milby (14), who reported 76% of the females and 79% of the males afflicted with slipped tendon on this ration. However, the extreme severity of the cases that did develop is demonstrated by the high mortality in this pen after the fourth week.

The results in Pen 4 indicate that a higher percentage of slipped tendon may occur when meat scrap and fish meal are used to replace milk and inorganic salts as sources of protein and phosphorus in the ration. A possible explanation of this is the presence of coarse particles of bone in the meat scrap, which could be picked out from the mash by the chicks. The phosphorus intake of some of the chicks might thus be higher and that of others consequently lower than that indicated by the analysis of the ration. However, it is also possible that a variation in the source of protein and minerals is responsible for the increased incidence of slipped tendon. If this is the case, it is in accord with the findings of

Schaible, Moore and Conolly (19) who report the influence of the source of protein, in a high mineral ration, on the incidence of perosis.

The high mortality in this pen occurred in the first two weeks and is not significantly associated with the development of slipped tendon as in the case of Pen 3.

EXPERIMENT II (Nov. 24/34 - Jan. 19/35)

Object

To determine and compare the incidence of slipped tendon in chicks on two rations, (No. 20 and No. 40), both devised by the University of Alberta, on which varying degrees of incidence of perosis have been reported from various parts of the Province.

No alterations were made in the general procedure as outlined previously. Only two pens were used in this experiment. Each pen contained 24 chicks of uniform size.

Rations

Table 6

Constituents of the rations

Feeds	Pen No. 20	Pen No. 40
Yellow Cornmeal	45	15
Bran	5	
Alfalfa L. & B. Meal	5	7
Wheat Chop		20
Oat Chop		20
# Oat Groats	15	
Barley Chop		10
Powdered Skim-milk	6.25	5
Meat Scrap	6.25	10
Fish Meal	12.50	10
$CaCO_3$	2.5	
NaCl	1	1
Cod Liver Oil	1.5	2
	100	100

#Finely ground hulled oats.

Table 7

Approximate analysis of the rations

Ration	% Protein	% Calcium	% Phosphorus
No. 20	22.3	2.1	.67
No. 40	22.7	1.25	.78

Results of Experiment II

Table 8

Average weights

Pen No.	Sex	2 wks.	4 wks.	6 wks.	8 wks.	No. in pen at 8 wks.
20	Male	93.2	273.3	547.8	869.7	12
	Female	85.6	256.3	501.0	764.8	9
40	Male	93.4	284.8	580.7	871.2	10
	Female	96.8	262.3	501.5	729.7	10

All birds were well feathered at eight weeks of age. It will be noted from Table 8 that exceptionally good growth was obtained on both these rations. Three chicks died in each pen, and these before two weeks of age.

Table 9

Incidence of Perosis

	Pen 20				Pen 40			
Age	No. Chicks	Cases of Perosis	Recoveries	Slipped Tendon	No. Chicks	Cases of Perosis	Recoveries	Slipped Tendon
1 day	24				23			
2 wks.	21				20			
4 wks.	21	2			20	3		
6 wks.	21	2	1	1	20	3	2	1
8 wks.	21	2	1	1	20	3	2	1
Total		2	1	1		3	2	1
Slipped tendon		- 4.8%				5%		
Mortality		-12.5%				13%		

Discussion of Results

From Table 9 it will be seen that under the conditions of this experiment the incidence of perosis is very low on both these rations, only one case of slipped tendon developing on each, in addition to one case of twisted legs on Ration No. 20 and two cases on No. 40. This low incidence of perosis in chickens making extremely rapid growth is in agreement with the findings of Parkhurst and McMurray (16) who reported that the rate of growth had no material effect on the occurrence of perosis. Crowded conditions, however, are considered by Hunter and Funk (9) to be important contributing factors in the development of slipped tendon, and it is possible that under such conditions, which are quite common on many poultry farms, the incidence of slipped tendon on these two rations might be considerably higher than reported in this study.

EXPERIMENT III (Dec. 18/34 - Feb. 13/35)

Objects

(1) To confirm results obtained in Experiment I.

(2) To determine if Marmite, when incorporated in a perosis-producing ration, contained a factor active in preventing slipped tendon.

(3) To investigate the importance of wire floors in the production of slipped tendon.

The chicks in each pen had access to only one-half of a section in the heated brooder during the first four weeks. The

division made in the section interferred in no way with the brooding conditions, other than to reduce the space available to each group. All pens were kept on wire floors with the exception of Pen 8. In this pen the wire floor was covered with double burlap for the first six weeks.

Rations

Pen 5 - Perosis-producing ration (high phosphorus), plus Marmite.

6 - Perosis-producing ration, plus rice bran (preventive).

7 - Same as 5, (high phosphorus), no preventive.

8 - Same as 7.

Table 10

Constituents of the rations

Feeds	Pen 5	6	7	8
Yellow Cornmeal	65	53.5	68.5	68.5
Alfalfa L. & B. Meal	5		5	5
Rice Bran		20		
Powdered Skim-milk	20	20	20	20
Marmite	3.5			
$Ca_3(PO_4)_2$	3	3	3	3
NaH_2PO_4	1.5	1.5	1.5	1.5
NaCl	1	1	1	1
Cod Liver Oil	1	1	1	1
	100	100	100	100

Ration 6 is the same as Ration 2 in Experiment I.
Rations 7 and 8 are the same as Ration 3, Experiment I.

Table 11
Approximate analysis of the rations

Rations	% Protein	% Calcium	% Phosphorus
5	15.15	1.50	1.37
6	14.66	1.42	1.53
7	14.12	1.50	1.32
8	14.12	1.50	1.32

This table was calculated from Table 1.

Results of Experiment III

Table 12

Average weights

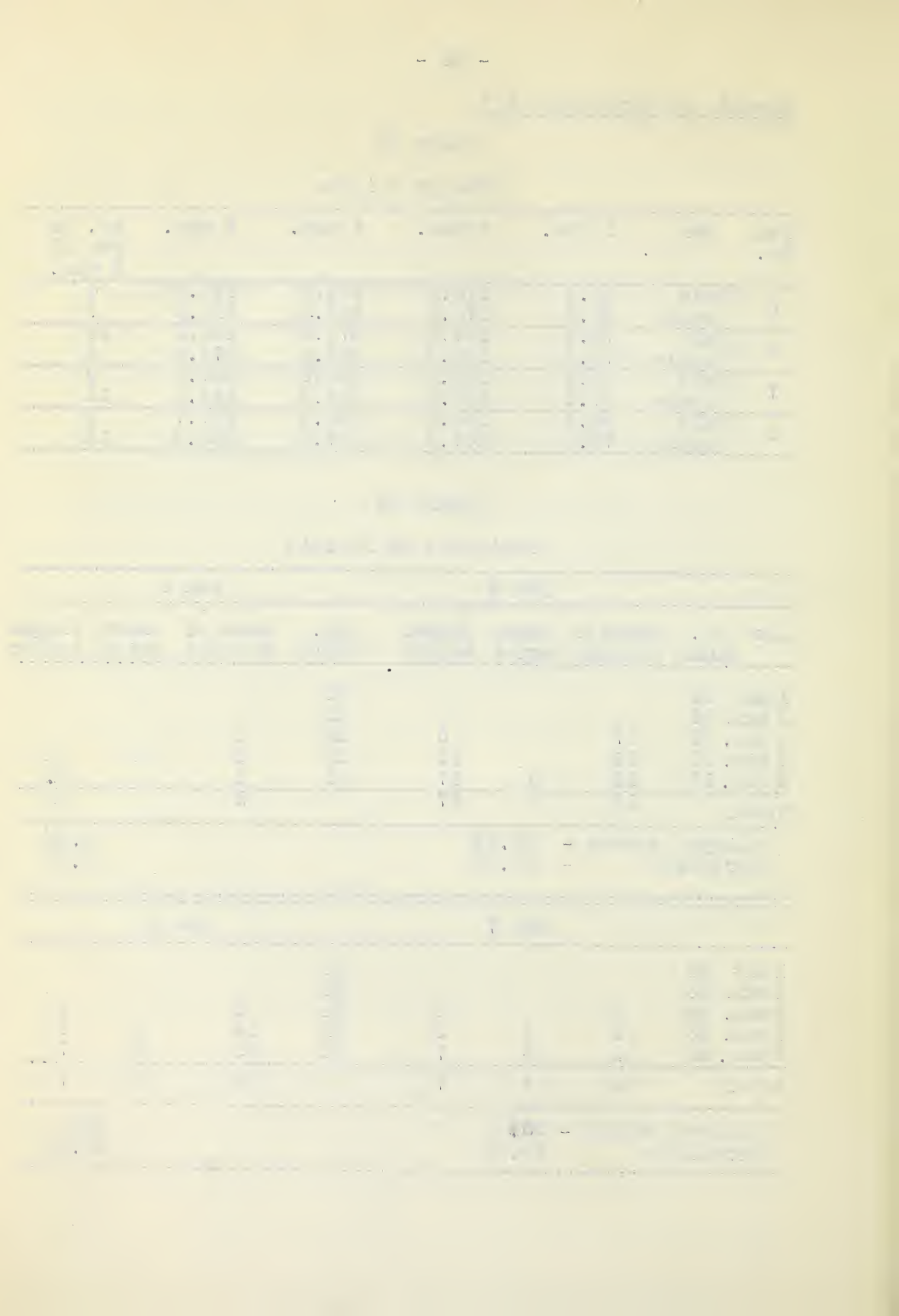
Pen No.	Sex	2 wks.	4 wks.	6 wks.	8 wks.	No. in pen at 8 wks.
5	Male	82.8	170.5	378.0	590.3	4
	Female	85.8	172.1	343.3	516.0	9
6	Male	79.3	177.8	377.8	602.1	16
	Female	71.2	150.8	306.4	473.0	5
7	Male	78.8	165.6	369.9	607.3	9
	Female	67.2	140.9	304.3	493.3	11
8	Male	68.3	124.3	285.0	507.7	3
	Female	75.0	147.9	307.0	522.8	13

Table 13

Incidence of Perosis

	Pen 5				Pen 6			
Age	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon
1 day	28				26			
2 wks.	26				23			
4 wks.	23	17		5	22	1		
6 wks.	21	18		12	22	1		1
8 wks.	13	18	1	17	21	1		1
Total		18	1	17		1		1
Slipped tendon -			65.4%					4.3%
Mortality -			53.6%					19.2%

	Pen 7				Pen 8			
1 day	28				28			
2 wks.	26				24			
4 wks.	25	6		2	24	8		3
6 wks.	23	8	2	5	21	14	1	6
8 wks.	20	11	3	7	16	15	3	7
Total		11	3	7		15	3	7
Slipped tendon -			25%					25%
Mortality			28.6%					42.9%



Discussion of Results

A comparison of Pens 5 and 7 indicates an increase in the incidence of perosis obtained by the addition of 3.5% Marmite (in Pen 5) to the original perosis-producing ration fed to Pen 7. There is also an increase in the percentage of actual slipped tendon, only 7 cases occurring in Pen 7, and 17 in Pen 5. The disorder also made its appearance more rapidly in Pen 5, where 17 chicks were affected by the fourth weeks, while in Pen 7 only 6 chicks were affected up to this time.

Marmite is a commercial product prepared, under a patented process, from yeast by digestion or autolysis. The nitrogen present (6.23%) is largely in the form of amino nitrogen, as a water solution of Marmite gives no precipitate with Trichloro-acetic acid. The addition of 3.5% Marmite, replacing an equal amount of yellow corn, raised the protein level of the ration slightly but did not vary the level of calcium and phosphorus, appreciably. At the present time no satisfactory explanation for the action of Marmite in increasing the production of slipped tendon can be given.

The results in Pen 6 confirm the findings obtained in Pen 2 in the first series of experiments, that, by the addition of rice bran to a perosis-producing ration, slipped tendon may be almost completely prevented.

Pen 7 shows an even lower percentage of slipped tendon than was produced on a similar ration in Exp. I (Pen 3), and a greater variation from the results obtained by Milby (14) for White Leghorns on the same ration. These results are not in accord with those of Bethke and Record (1) who report the

incidence of perosis to be higher in the heavier than in the lighter breeds. Payne et al (18) also report a higher incidence of "hock joint trouble" among Rhode Island Red chicks than among White Leghorns.

The results obtained in Pens 7 and 8, receiving the same ration but on different floors indicate that brooding on wire floors is not an important contributing factor in the production of slipped tendon. Hunter and Funk (9) obtained a reduction of 50% in the occurrence of slipped tendon by replacing the wire floor with a solid floor, the latter being covered with sand. The results obtained in the present experiment would indicate that the beneficial results obtained by Hunter and Funk may have been due not to the type of floor used but to the ingestion of sand. However, in the present experiment the chicks on the burlap floor (Pen 8) did have access to their own droppings which would contain calcium and phosphorus, and it is possible that these may have been ingested in sufficient amounts, to raise the mineral level of the diet, ~~sufficiently~~ and thus ~~to~~ nullify the beneficial effects of the soft floor.

The results of this series also confirm those of Parkhurst and McMurray (16) that crowded conditions and lack of exercise are not contributing factors of any importance in the production of perosis.

EXPERIMENT IV (Jan. 20 - Mar. 2/35)

Objects

(1) To determine the incidence of perosis in chicks on ration No. 40, under more confined conditions of brooding, and on various modifications of ration 40, in which feeds readily available to the poultry producers in this Province, were utilised.

The space allotted to each pen was, as in Exp. III, only half a section.

Table 14
Constituents of the rations

Feeds	Pen 9#	10	11	12
Yellow Cornmeal	15	15	15	15
Alfalfa L. & B. Meal	7	7	7	7
Wheat Chop	20	20	20	20
Oat Chop	20	20	20	20
Barley Chop	10	12	11	9
Powdered Skim-milk	5	5	5	5
Meat Scrap	10		10	
"Super 70" Meat Scrap		7	8	14
Fish Meal	10	10		
Linseed Oil Meal				5
$CaCO_3$		1	1	2
NaCl	1	1	1	1
Cod Liver Oil	2	2	2	2

Same as Ration 40 in Exp. II.

Table 15

Approximate analysis of the rations

Rations	% Protein	% Calcium	% Phosphorus
9	22.7	1.25	.78
10	22.4	1.15	.58
11	21.8	1.29	.63
12	22.3	1.19	.44

Results of Experiment IV

Table 16

Average weights

Pen No.	Sex	2 wks.	4 wks.	6 wks.	No. in pen at 6 wks.
9	Male	83.6	234.0	478.8	10
	Female	82.1	245.2	473.5	12
10	Male	81.1	244.9	497.3	16
	Female	88.0	246.1	431.1	7
11	Male	77.0	214.8	458.5	6
	Female	86.2	231.7	498.8	15
12	Male	75.6	217.1	475.0	8
	Female	67.7	185.8	383.4	10

Table 17
Incidence of Perosis

	Pen 9				Pen 10			
Age	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon
1 day	25				25			
2 wks.	22				23			
4 wks.	22	2			23	2		
6 wks.	22	2	2		23	2	2	
Total		2	2			2	2	
Slipped tendon			- 0					0
Mortality			- 12%					8%

	Pen 11				Pen 12			
1 day	25				25			
2 wks.	21				18			
4 wks.	21	1			18			
6 wks.	21	1			18			
Total		1						
Slipped tendon			- 0					0
Mortality			- 16%					28%

Discussion of Results

The results obtained in Pen 9 are in agreement with those obtained in Pen 40, Exp. II, with respect to the low incidence of perosis. Under the more crowded conditions of this experi-

ment, only two cases of perosis developed, and both of these had recovered when examined at six weeks of age. These results again confirm the results of Parkhurst and McMurray (16) on the influence of crowded conditions. This low incidence of perosis in Pen 9 makes a comparison of the modifications of No. 40 used in Pens 10, 11 and 12 with the original No. 40, on the basis of incidence of perosis, of little value. Ration 12, however, has a slight advantage in this respect, as no cases of the deformity were observed. However, the growth on this ration was decidedly lower than that on the other three, in which there is little difference in average weight at six weeks.

As there was a considerable variation not only in size but also in body type of the birds supplied us for this experiment, too much significance should not be attached to the figures presented in Table 15, reporting average weights.

EXPERIMENT V (Feb. 19 - April 2/35)

Objects

(1) To determine the effect on the incidence of perosis of the addition of silica sand and of sodium silicate to a perosis-producing ration.

(2) To determine the effect of exercise on the incidence of perosis, in chicks fed a perosis-producing ration.

The preventive action of rice bran on the production of perosis has been reported by several workers (22) (23) (14) and has been confirmed in Pen 3, Exp. I, and Pen 6, Exp. II. During the analysis of rice bran it was noted that silica was an important constituent of the ash of rice bran, from a quantita-

tive point of view.

Titus (23) found the "preventive factor" of rice bran to be unextractable with ether, but retained in the ether extracted residue.

Hunter and Funk (9) obtained a reduction in the percentage of slipped tendon in chicks brooded on a solid floor covered with sand. The results obtained in Pen 8, Exp. III, of this series indicate the relative unimportance of type of floors as a contributing factor in the production of slipped tendon and the possibility that the beneficial effects obtained by these workers may have been due to the ingestion of sand picked up from the floor.

Milby (14) reports good growth and no perosis on a ration containing 8% dry sandy loam.

King, Stantial and Dolan (12) have reported the results of feeding various levels of particulate and of soluble silica to rabbits. They found that although the level of silica in the blood remained fairly constant with changes in the silica content of the ration, the absorption of particulate and soluble silica from the digestive tract, and also the excretion of silica in the urine, increased as the level of silica in the diet was increased.

In view of these findings it was considered possible that silica might play some part in the prevention of perosis, and Experiment V was, therefore, designed to examine this possibility.

Hunter and Funk (9) have suggested lack of exercise as an important contributing factor in the production of slipped tendon. A study of the effect of exercise was, therefore, included in

this experiment, (Pen 16). For the first four weeks the chicks in this pen were given the opportunity to scratch four hours a day in a litter of shredded wood which covered a burlap mat on the floor of the pen. During the exercising period the feed troughs were removed and a handful of feed scattered in the litter. For the remainder of the day the chicks remained on the wire floor. Shredded wood was chosen for litter as being a material not likely to be ingested to any extent by the chicks.

Rations used

No. 13 - Perosis-producing ration, (Modification of No. 40).

No. 14 - Same as 13, plus Silica (sand).

No. 15 - Same as 13, plus sodium silicate (water glass).

No. 16 - Same as 13.

Table 18

Constituents of the rations

Feeds	Pen 13 & 16	14	15
Yellow Cornmeal	64	62	57.5
Alfalfa L. & B. Meal	5	5	5
Powdered Skim-milk	5	5	5
Meat Scrap	10	10	10
Fish Meal	10	10	10
Bone Meal	1	1	1
NaH_2PO_4	2	2	2
NaCl	1	1	1
Cod Liver Oil	2	2	2
# Silica (SiO_2)		2	
## Sodium Silicate			6.5

#Builder sand passed through a No. 80 screen, boiled with dilute acid, and thoroughly washed with distilled water.

##Water glass, 29.3% SiO_2, used in a quantity to furnish SiO_2 in the proportion of 2% of the ration. The water glass was thoroughly mixed with the cod liver oil before being added to the mash, so as to obtain a uniform distribution in the ration.

Table 19

Approximate analysis of the rations

Ration	% Protein	% Calcium	% Phosphorus
13 & 16	21.11	1.43	1.16
14	20.91	1.43	1.15
15	20.86	1.43	1.15

Results of Experiment V

Table 20

Average Weights

Pen No.	Sex	2 wks.	4 wks.	6 wks.	No. in pen at 6 weeks
13	Male	85.0	188.0	328.2	13
	Female	87.3	178.1	284.1	8
14	Male	88.3	191.3	341.6	8
	Female	92.2	178.5	263.0	10
15	Male	81.3	170.8	285.2	9
	Female	77.4	158.6	283.6	7
16	Male	85.1	174.1	273.1	11
	Female	88.0	175.3	291.7	7

As will be seen in Table 20, the average weights in Pen 15 are lower at two weeks than those of other pens. Since it was desired to obtain the same rate of growth in all pens, and since no perosis had developed in Pen 15 at this time (See Table 21), the water glass was reduced to 3.5%. However, due to the development of perosis in Pen 15 in the third week, the water glass was restored to the original level, at the beginning of the fourth week. At this time the level of silica in Pen 14 was also raised to 5%, in an effort to check the development of perosis.

The average weights of all groups at six weeks are very low, considering the high protein level of the rations. After

the beginning of the fourth week, with perosis affecting 50% or more in each pen, there was a pronounced tendency for the chicks in all groups to remain in a resting position. The consequent low intake of feed may account in part for the poor growth obtained.

Table 21

Incidence of Perosis

	Pen 13			Pen 14			
Age	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon	No. Chicks	Cases of Perosis	Recoveries	Slipped tendon
1 day	26				26			
2 wks.	26	1		1	23	2		
4 wks.	26	16		3	22	14		3
6 wks.	21	17		10	18	17	1	9
Total		17		10		17	1	9
		Slipped tendon - 38.5%						39.1%
		Mortality - 19.2%						30.8%

	Pen 15				Pen 16			
1 day	26				26			
2 wks.	25				25	2		
4 wks.	23	14		4	23	15		4
6 wks.	16	18	2	9	18	20		8
Total		18	2	9		20		8
		Slipped tendon - 36%						32%
		Mortality - 38.5%						30.8%

Discussion of Abnormalities

From Table 21 it will be seen that the total cases of perosis are approximately the same for Pens 13, 14 and 15, and slightly greater for Pen 16. No significant difference in the percentage of slipped tendon is obtained in Pen 14 by the addition of silica, or in Pen 15 by the addition of sodium silicate.

These results are in accord with the results of Hunter, Knandel and Dutcher (10) who obtained no beneficial results by the addition of the ash of oat feed to a perosis-producing ration, although 20% of oat feed was found to possess the power to prevent "hock disease".

The percentage of slipped tendon is reduced by only 6% in Pen 16, receiving exercise during the first four weeks. This difference is not significant and confirms the results of Parkhurst and McMurray (16) who found that lack of exercise was not a contributing factor of any importance.

MECHANISM OF THE DEVELOPMENT OF SLIPPED TENDON

The symptoms observed during the development of perosis, as reported by several workers (3) (9) (11) (14) (17) (23) have already been reviewed. The observations made during the experiments herein reported, however, fail to confirm in some instances, and definitely contradict in others, the observations of these workers.

Milby (14) in reporting his own observations states that "the first observable symptom is usually a slight puffiness about the hock joint." Payne (17), Hunter and Funk (9), Titus (23), Insko et al (11), report a definite enlargement of the hock joint with the onset of perosis. Payne (17), Titus (23), and Insko et al (11) observed discoloration in some cases of enlarged hock joint, due to hemorrhage in the tissues surrounding the joint. During this series of experiments, however, no cases of enlargement or of discoloration of the hock joint were observed at the time of the onset of perosis. The only abnormality noted at this time was a decided flattening of the hock joint.

Payne (17) considers that in some cases of "enlarged hock" the gastrocnemius tendon may slip from the condyles of the tibia resulting in the development of a permanent deformity. Titus (23) considers the slipping of the tendon to be due either to a slipping of the articular cartilage on the distal end of the tibia, or to a decided bending of the diaphysis of the distal end of the tibia. In no case in this series of experiments, however, was the bending of the tibia ever noted before the slipping of the tendon although in some cases a bowing of the metatarsus occurred before or without a slipping of the tendon. Milby (14) considers the bending of the tibia to be the result rather than the cause of the displacement of the tendon.

All the larger tendons, leading from the muscles in the upper leg to the metatarsus and the foot, pass through a ring of cartilage on the posterior surface of the proximal end of the metatarsus. This ring is completed by the attachment of the lower end of the Achilles tendon to the outer edges of the ring of cartilage. By this structural arrangement all the tendons passing over the distal end of the tibia are held in place. A rotation or twisting of the metatarsus, (with a consequent flattening of the hock joint), would therefore tend to draw the main tendons out of alignment with the bones. In mild cases this twisting of the metatarsus apparently ceases, and no permanent deformity results. In cases which become progressively worse, however, the metatarsus may continue to rotate until the main tendons are pulled over the edge of one of the condyles on the distal end of the tibia. When this occurs the tendons will, of course, become useless

Leg Bones of Chickens (6 wks. of age).

1. Normal.

2. The development of perosis. Note the twisted metatarsus.

3. The final stage of perosis, slipped tendon. Note the displacement of the tendon sheath to the side of the joint, the proliferation around the hock joint, the bent tibia, and the twisted metatarsus.

in flexing and straightening the lower leg and foot, and a permanently deformed condition will result. These observations are in accord with those of Doyle (3) who considers this type of "leg weakness" to be essentially a bending or torsion of the bones which form the hock joint, with a consequent displacement of the Achilles tendon. This improper alignment of the two bones and the weight of the bird pressing on the deformed limb, probably combine to produce the lateral bending of the epiphysis at the distal end of the tibia and the bowing of the metatarsus, which were observed in some of the advanced cases.

Dissection studies of permanently deformed legs tend to confirm the above theory of the mechanism by which slipped tendon is produced. In the specimens examined, the cartilagenous ring was found to be properly formed, and to enclose the tendons in their normal position. However, the alignment of the tibia and metatarsus was found to be abnormal, the metatarsus being rotated so that the ring of cartilage, with its enclosed and attached tendons, was shifted to one side of the joint. In this position it is obvious the tendons could not perform their function adequately, and the leg would therefore be rendered useless. Plates illustrating normal and deformed leg bones are shown on the opposite page.

From our observations on the mechanism involved in the development of perosis it is concluded that the essential factor in the series of events leading to slipped tendon, is the rotation of the metatarsus. This in turn causes sufficient displacement of the cartilage enclosing the tendons, to pull the main tendons from the groove formed by the condyles at

the distal end of the tibia, and results in a disabled and permanently deformed condition.

SUMMARY AND CONCLUSIONS

(1) In rations otherwise satisfactory for normal growth, a high level of phosphorus was found to be associated with a high incidence of perosis.

(2) The source of protein and inorganic phosphorus was found to have some influence on the incidence of perosis.

(3) Rice bran, when comprising 20% of a high-phosphorus ration, was effective in reducing the incidence of perosis.

(4) Marmite, when added at the rate of 3.5% to a high-phosphorus ration, increased the incidence of perosis and the percentage of slipped tendon. No explanation for this action of marmite can be given.

(5) The additional exercise obtained when chicks were allowed to scratch in a litter of shredded wood for four hours a day during the first four weeks did not result in a decrease in the incidence of perosis.

(6) The incidence of perosis in chicks fed a perosis-producing ration, was not reduced by covering the wire floor with burlap for the first six weeks.

(7) The incidence of perosis on two standard chick rations tested, was found to be very low. The revisions made in one of these (No. 40) did not definitely prevent perosis, and in some cases resulted in decreased rate of growth.

(8) The addition of sand (SiO_2) or of sodium silicate to a perosis-producing ration did not result in a reduction in the incidence of perosis.

(9) As a result of observations and dissection studies, perosis is considered to be primarily a disorder of the leg bones of the chick. The initial outward symptom, produced by a rotation of the metatarsus, is a decided flattening of the hock-joint. In the intermediate stages, depending on the extent of the twisting of the metatarsus, this bone may become bent or bowed.

In the final stage, referred to as "slipped tendon" and produced by the persistent rotation of the metatarsus, the tendons are pulled over the edge of the condyles to one side of the joint and the leg is carried in an abnormal position. In this final stage the epiphysis at the distal end of the tibia may, in some cases, be bent laterally in the direction in which the tendon slips and the metatarsus may also be bowed.

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